O I P E
MAR 2 5 1998
PAT & TRADEMARK OFFICE

5786069
9/8/98

Patent
Attorney's Docket No. 024444-264

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of Björn LJUNGBERG et al. Application No.: 08/703,965 Filed: August 28, 1996 For: COATED TURNING INSERT	**Allowed: February 18, 1998** Group Art Unit: 1317 Examiner: A. Turner

RECEIVED
APR 2 1 1998
Publishing Division
Corres/Allowed Files (02)

CLAIM FOR CONVENTION PRIORITY

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed:

Swedish Patent Application No. 9503056-5

Filed: September 1, 1995

In support of this claim, enclosed is a certified copy of said prior foreign application. Said prior foreign application was referred to in the oath or declaration. Acknowledgment of receipt of this certified copy is requested.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

Date: March ~~16~~ 25, 1998

By: Peter K Skiff
Peter K. Skiff
Registration No. 31,917

P.O. Box 1404
Alexandria, Virginia 22313-1404
(703) 836-6620

PRV

PATENT- OCH REGISTRERINGSVERKET
Patentavdelningen

Intyg
Certificate

Härmed intygas att bifogade kopior överensstämmer med de handlingar som ursprungligen ingivits till Patent- och registreringsverket i nedannämnda ansökan.

This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.

(71) Sökande Applicant (s) — Sandvik AB, Sandviken SE

(21) Patentansökningsnummer Patent application number — 9503056-5

(86) Ingivningsdatum Date of filing — 1995-09-01

Stockholm, 1998-02-19

För Patent- och registreringsverket
For the Patent- and Registration Office

Åsa Dahlberg

Åsa Dahlberg

Avgift
Fee 170:-

Coated turning insert

The present invention relates to a coated cutting tool (cemented carbide insert) particularly useful for turning in hot and cold forged low alloyed steel components like gear rings and axles used in the automotive industry.

Low alloyed steel is a material which, in general, is difficult to machine with coated or uncoated cemented carbide tools. Smearing of work piece material onto the cutting edge and flaking of the coating often occur. The cutting conditions are particularly difficult during the turning of forged low alloyed components under wet conditions (using coolant). The hot forged skin (0.05-0.2 mm) is generally decarburized and thus softer than the bulk material due to a mainly ferritic structure. The cold forged skin (less than 0.05 mm) is cold-worked and, thus, harder due to a deformation hardening effect. Furthermore, the ferrite/pearlite bulk structure of such a material is often "ferrite-striated", i. e. the ferrite and pearlite are forming parallel stripes. This mixture of hard and soft materials makes the cutting conditions very difficult.

Further, when turning low alloyed steels by coated cemented carbide tools the cutting edge is worn by chemical wear, abrasive wear and by a so called adhesive wear. The adhesive wear is often the tool life limiting wear. Adhesive wear occurs when fragments or individual grains of the layers and later also parts of the cemented carbide are successively pulled away from the cutting edge by the work piece chip formed. Further when wet turning is employed the wear may also be accelerated by an additional wear mechanism. Coolant and work piece material may penetrate into the cooling cracks of the coatings. This penetration often leads to a chemical reaction between work piece material and coolant with the cemented carbide. The Co-binder phase may oxidise in a zone near the crack and along the interface between the coating and the cemented carbide. After some time coating fragments are lost piece by piece.

Swedish patent application 9501286-0 discloses a coated cutting insert particularly useful for dry milling of grey cast iron. The insert is characterised by a straight WC-Co cemented

carbide body and a coating including a layer of $TiC_xN_yO_z$ with columnar grains and a top layer of fine grained α-Al_2O_3.

Swedish patent application 9502640-7 discloses a coated turning insert particularly useful for intermittent turning in low alloyed steel. The insert is characterised by a WC-Co cemented carbide body having a highly W-alloyed Co-binder phase and a coating including a layer of $TiC_xN_yO_z$ with columnar grains and a top layer of a finegrained, textured α-Al_2O_3.

It has surprisingly been found that by replacing the textured α-Al_2O_3-layer of the above mentioned patent application with a κ-Al_2O_3-layer a cutting tool with excellent properties for turning forged components in low alloyed steel can be obtained.

Fig 1 is a micrograph in 5000X magnification of a coated insert according to the present invention in which

A - cemented carbide body

B - $TiC_xN_yO_z$-layer with equiaxed grains

C - $TiC_xN_yO_z$-layer with columnar grains

D - κ-Al_2O_3-layer with columnar like grains

E - TiN-layer (optional)

According to the present invention a turning tool insert is provided with a cemented carbide body of a composition 5 - 11, preferably 5 - 8, most preferably 6.5 - 8, wt-% Co, 2 - 10, preferably 4 - 7.5, most preferably 5 - 7, wt-% cubic carbides of the metals from groups IVb, Vb or VIb of the periodic table of elements preferably Ti, Ta and/or Nb and balance WC. The grain size of the WC is in the range of about 2 µm. The cobalt binder phase is highly alloyed with W. The content of W in the binder phase can be expressed as the

CW-ratio= M_s /(wt-% Co · 0.0161),

where M_s is the measured saturation magnetization of the cemented carbide body and

wt-% Co is the weight percentage of Co in the cemented carbide. The CW-ratio is a function of the W content in the Co binder phase. A low CW-ratio corresponds to a high W-content in the binder phase.

It has now been found according to the invention that improved cutting performance is achieved if the cemented carbide

body has a CW-ratio of 0.76 - 0.92, preferably 0.80 - 0.90. The cemented carbide body may contain small amounts, <1 volume-%, of η-phase (M_6C), without any detrimental effect. In a preferred embodiment an about 15 - 35 µm thick surface zone depleted of cubic carbides and often enriched (generally more than 25 % enrichment) in binder phase can be present according to prior art such as disclosed in US 4,610,931. In this case the cemented carbide may contain carbonitride or even nitride.

The coating comprises

- a first (innermost) layer of $TiC_xN_yO_z$ with x+y+z=1, preferably z<0.5, with a thickness of 0.1 - 2 µm and with equiaxed grains with size <0.5 µm

- a layer of $TiC_xN_yO_z$ x+y+z=1, preferably with z=0 and x>0.3 and y>0.3, with a thickness of 3 - 15 µm, preferably 5 - 8 µm, with columnar grains and with an average diameter of about <5 µm, preferably <2 µm.

- a layer of a smooth, fine-grained (grain size about 0.5 - 2 µm) Al_2O_3 consisting essentially of the κ-phase. However the layer may contain small amounts, 1-3 vol-%, of the θ- or the α-phases as determined by XRD-measurement. The Al_2O_3-layer having a thickness of 1 - 6 µm, preferably 1 - 3 µm, and a surface roughness $R_{max} \leq 0.4$ µm over a length of 10 µm. Preferably, this Al_2O_3-layer is the outermost layer but it may also be followed by further layers such as a thin (about 0.1 - 1 µm) decorative layer of e g TiN.

According to method of the invention a WC-Co-based cemented carbide body having a highly W-alloyed binder phase with a CW-ratio according to above and preferably with a binder phase enriched surface zone is coated with

- a first (innermost) layer of $TiC_xN_yO_z$ with x+y+z=1, preferably z<0.5, with a thickness of 0.1 - 2 µm, and with equiaxed grains with size <0.5 µm using known CVD-methods.

- a layer of $TiC_xN_yO_z$ x+y+z=1, preferably with z=0 and x>0.3 and y>0.3, with a thickness of 3 - 15 µm, preferably 5 - 8 µm, with columnar grains and with an average diameter of about <5 µm, preferably <2 µm, using preferably MTCVD-technique (using acetonitrile as the carbon and nitrogen source for forming the layer in the temperature range of 700 - 900 °C). The

exact conditions, however, depend to a certain extent on the design of the equipment used.

- an outer layer of a smooth Al_2O_3-layer essentially consisting of κ-Al_2O_3 is deposited under conditions disclosed in EP-A-523 021. The Al_2O_3-layer has a thickness of 1 - 6 µm, preferably 1 - 3 µm, and a surface roughness $R_{max} \leq 0.4$ µm over a length of 10 µm. The smooth coating surface can be obtained by a gentle wet-blasting the coating surface with fine grained (400 - 150 mesh) alumina powder or by brushing the edges with brushes based on e g SiC as disclosed in Swedish patent application 9402543-4.

Example 1

A. Cemented carbide turning tool inserts of style CNMG 120408-PM with the composition 7.5 wt-% Co, 1.8 wt-% TiC, 0.5 wt-% TiN, 3.0 wt-% TaC, 0.4 wt-% NbC and balance WC, with a binder phase highly alloyed with W corresponding to a CW-ratio of 0.88 were coated with a 0.5 µm equiaxed TiCN-layer (with a high nitrogen content corresponding to an estimated C/N-ratio of 0.05) followed by a 7 µm thick TiCN-layer with columnar grains by using MTCVD-technique (temperature 885-850 °C and CH_3CN as the carbon/nitrogen source). In subsequent steps during the same coating cycle, a 1.5 µm thick layer of Al_2O_3 was deposited using a temperature 970 °C and a concentration of H_2S dopant of 0.4 % as disclosed in EP-A-523 021. A thin (0.5 µm) decorative layer of TiN was deposited on top according to known CVD-technique. XRD-measurement showed that the Al_2O_3-layer consisted of 100 % κ-phase. The cemented carbide body had a surface zone about 25 µm thick, depleted from cubic carbides and with an about 30 % enrichment in binder phase. The coated inserts were brushed by a nylon straw brush containing SiC grains. Examination of the brushed inserts in a light microscope showed that the thin TiN-layer had been brushed away only along the cutting edge leaving there a smooth Al_2O_3-layer surface. Coating thickness measurements on cross sectioned brushed samples showed no reduction of the coating along the edge line except for the outer TiN-layer that was removed.

B.) A strong competitive cemented carbide grade in style CNMG 120408 from an external leading carbide producer was selected for comparison in a turning test. The carbide had a composition of 9.8 wt-% Co, 0.2 wt-% TiC, 2.0 wt-% TaC, balance WC and a CW-ratio of 0.86. The insert had a coating consisting of a 5 µm TiCN-layer followed by a 1.5 µm thick Al_2O_3-layer and a 0.5 µm TiN-layer. Light microscope examination showed that the insert had not been smoothed along the edgeline after the coating step.

Insert from A was compared against insert from B in a turning test in a hot forged ring gear (diameter 206 mm, in TSCM815H material). Each turning cycle performed on each component consisted of one phasing cut, one longitudinal cut and one chamfering cut. Feed = 0.35 mm/rev and a cutting speed of around 230 m/min.

First, 150 components were machined with both insert A and B and obtained flank wear was measured and compared. Since the wear was much less developed on insert A it was allowed to cut further components, altogether 354 components. Obtained flank wear is shown in the table below:

	Number of components	measured flank wear
insert A (acc. to invent.)	150	0.07 mm
------"---------	354	0.08 mm
insert B (external grade)	150	0.10 mm

Microscope examination of the tested inserts showed tiny flaking on insert B while no visible flaking had occurred on insert A, not even after 354 machined components.

It is obvious from the obtained flank wear that insert A according to the invention is superior and possesses longer tool life.

Example 2

D.) A strong competitive cemented carbide grade in style CNMG 120408 from another external leading carbide producer was

selected for comparison in a turning test. The chemical composition of the cemented carbide was: 7.6 wt-% Co, 2.4 wt-% TiC, 0.5 wt-% TiN, 2.4 wt-% TaC, 0.3 wt-% NbC and balance WC. The cemented carbide had a surface zone, about 20 µm thick, depleted from cubic carbides. The composition of the cemented carbide was similar to that of the invention but had a higher CW-ratio of 0.93 and a different coating which consisted of a 5 µm TiCN-layer followed by a 3.5 µm TiC-layer, a 1.5 µm Al_2O_3-layer and a 0.5 µm TiN-layer. Light microscope examination showed that the insert had not been smoothed along the edgeline after the coating step.

Insert from A and D were compared in a facing turning test in a hot forged ring gear (outer diameter of 180 mm and inner diameter of 98 mm in a SCr420H material). Feed = 0.25-0.35 mm/rev and cutting speed = 220 m/min. The inserts were run to a preset flank wear value of 0.08 mm and the number of produced component was the evaluation criteria.

	Number of components	measured flank wear
insert A edge 1 (acc. to invent.)	203	0.08 mm
------"--edge 2----	226	0.08 mm
insert D (external grade)	182	0.08 mm

Example 3

C.) Cemented carbide turning tool inserts of style WNMG 080408-PM with the same composition and CW-ratio of 0.88 as insert A were coated according to A. XRD-measurement showed that the Al_2O_3-layer consisted of 100 % κ-phase. The inserts were brushed according to A.

E.) An insert in style WNMG 080408 from the same cemented carbide producer as in D and with the same CW-ratio, carbide composition and coating as in D was selected for comparison in a turning test. Light microscope examination slowed that the

insert had not been smoothed along the edgeline after the coating step.

Insert from C and E were compared in a facing turning test of an forged axle (length of 487 mm and diameter of 27-65 mm, material 50CV4). Feed = 0.28-0.30 mm/rev and cutting speed = 160 m/min. Three axles were run per each cutting edge and the wear of the cutting edges was examined in a light microscope

insert C (acc. to invent.)	flank wear less than 0.07 mm no flaking
insert E (external grade)	flank wear less than 0.07 mm flaking and chipping along the edge

<u>Example 4</u>

F.) Cemented carbide turning tool inserts of style CNMG 120408-PM from the same batch as in A were coated according to Swedish patent application 9502640-7 with 0.5 equiaxed TiCN followed by a 7 µm thick layer TiCN with columnar grains, 1 µm equiaxed TiCN and a 4 µm thick 012-textured α-Al_2O_3. The inserts were wet-blasted using a water/Al_2O_3-slurry in order to smooth the coating surfaces.

G.) Cemented carbide turning tool inserts of style CNMG 120408-PM with the composition 6.5 wt-% Co and 8.8 wt-% cubic carbides (3.3 wt-% TiC, 3.4 wt-% TaC and 2.1 wt-% NbC) and balance WC were coated under the procedure given in A). The cemented carbide body had a CW-ratio = 1.0 and a surface zone about 23 µm thick depleted in cubic phase and enriched in binder phase. XRD-measurement showed that the Al_2O_3-layer consisted only of the κ-phase.

Inserts from A, F, G and B were compared in a turning test in a hot and cold forged ring gear in material SCr420H.

The ring had an outer diameter of 190 mm and an inner diameter of 98 mm. Each turning cycle performed on each component consisted of three phasing cuts and one longitudinal cut. Feed = 0.25-0.40 mm/rev and cutting speed around 200 m/min. 170 components were machined and the wear of the cutting edges was examined.

insert A (acc. to invent.)	no visible flaking of the coating, flank wear less than 0.07 mm
insert F (CW-ratio = 0.88)	some removal of the coating along the cutting edge, flank wear less than 0.08 mm
insert G (CW-ratio = 1.0)	substantial flaking along the cutting edge and flank wear more than 0.10 mm
insert B (external)	some removal of coating along the cutting edge, flank wear less than 0.08 mm

Although insert F produced according to the Swedish patent application 9502640-7 generally performs superior when turning low alloyed steels it can not always compete with insert A produced according to the present invention when turning some hot and cold forged low alloyed steel components.

Claims

1. A cutting tool insert for turning of forged components in low alloyed steel comprising a cemented carbide body and a coating characterised in that said cemented carbide body consists of WC, 5 - 11 wt-% Co and 2 - 10 wt-% cubic carbides of Ti, Ta and/or Nb and a highly W-alloyed binder phase with a CW-ratio of 0.76 - 0.92 and in that said coating comprises

- a first (innermost) layer of $TiC_xN_yO_z$ with a thickness of 0.1 - 2 µm, and with equiaxed grains with size <0.5 µm
- a layer of $TiC_xN_yO_z$ with a thickness of 3-15 µm with columnar grains with a diameter of about <5 µm
- an outer layer of a smooth, fine-grained (0.5 - 2 um) kappa-Al_2O_3-layer with a thickness of 1 - 6 µm.

2. Cutting insert according to claim 1 characterised in that the cemented carbide body has a surface zone 15 - 35 µm thick depleted from cubic carbides.

3. Cutting insert according to any of the preceding claims characterised in that the cemented carbide has the composition 6.5-8.0 wt-% Co and a CW-ratio of 0.76 - 0.90.

4. Cutting insert according to any of the preceding claims characterised in that the outermost layer is a thin 0.1 - 1 µm TiN-layer.

5. Cutting insert according to claim 4 characterised in that the outermost TiN-layer has been removed along the cutting edge.

6. Method of making a turning insert comprising a cemented carbide body and a coating characterised in that WC-Co-based cemented carbide body with a highly W-alloyed binder phase with a CW-ratio of 0.76 - 0.92 is coated with

- a first (innermost) layer of $TiC_xN_yO_z$ with a thickness of 0.1 - 2 µm, with equiaxed grains with size <0.5 µm using known CVD-methods
- a layer of $TiC_xN_yO_z$ with a thickness of 3 - 15 µm with columnar grains with a diameter of about <5 µm deposited by MTCVD-technique, using acetonitrile as the carbon and nitrogen source for forming the layer in a preferred temperature range of 850 - 900 °C.

- a layer of a smooth kappa-Al_2O_3 with a thickness of 1 - 6 µm.

7. Method according to the previous claim characterised in that said cemented carbide body has a binder phase enriched surface zone.

Abstract

The present invention discloses a coated turning insert particularly useful for intermittent turning in low alloyed steel. The insert is characterised by a WC-Co cemented carbide body having a highly W-alloyed Co-binder phase and a coating including an innermost layer of $TiC_xN_yO_z$ with columnar grains and a top layer of fine grained κ-Al_2O_3.

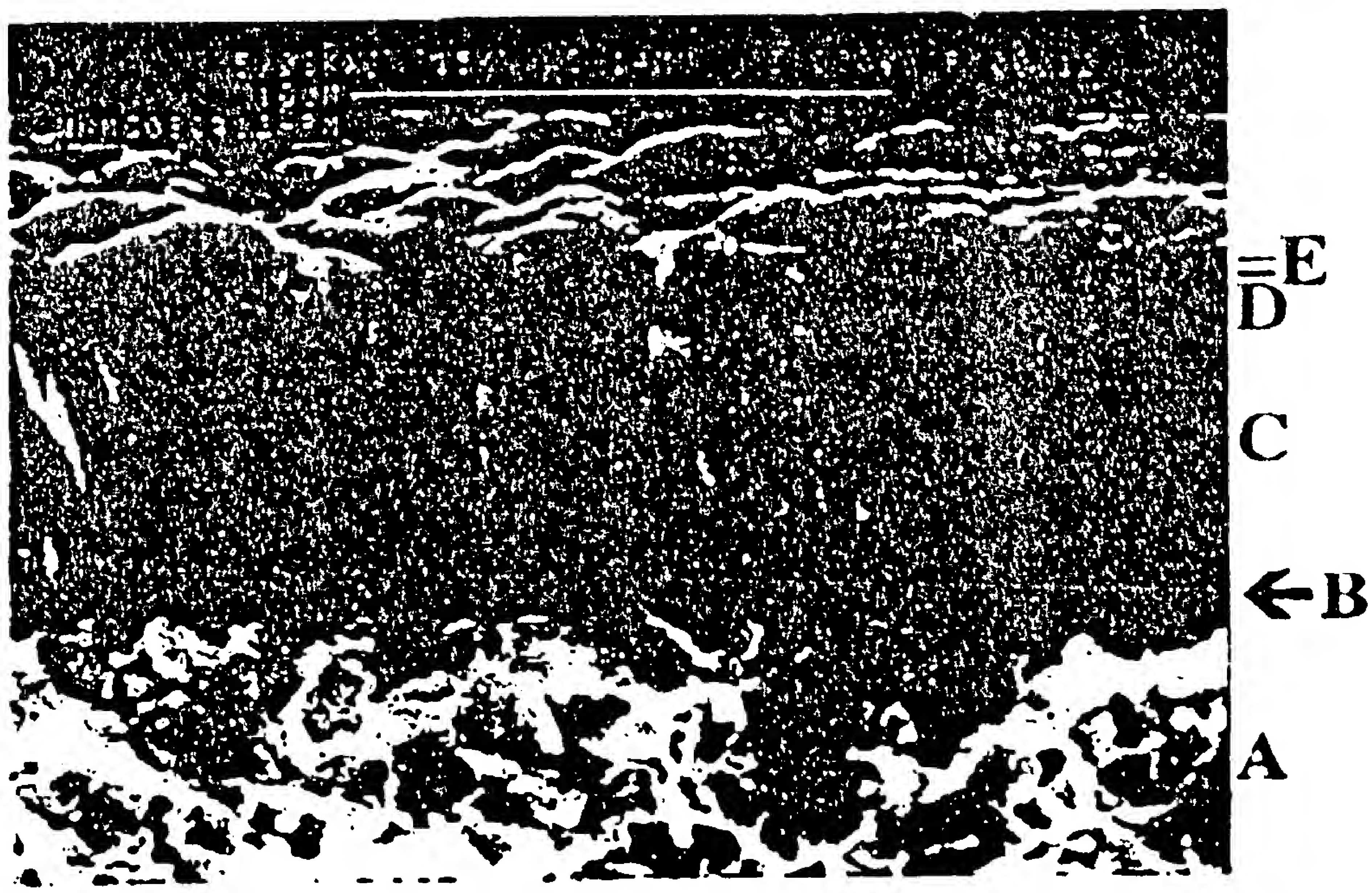

Fig. 1